CLASP/SJ observation of time variations of Lyman-alpha emissions in a solar active region

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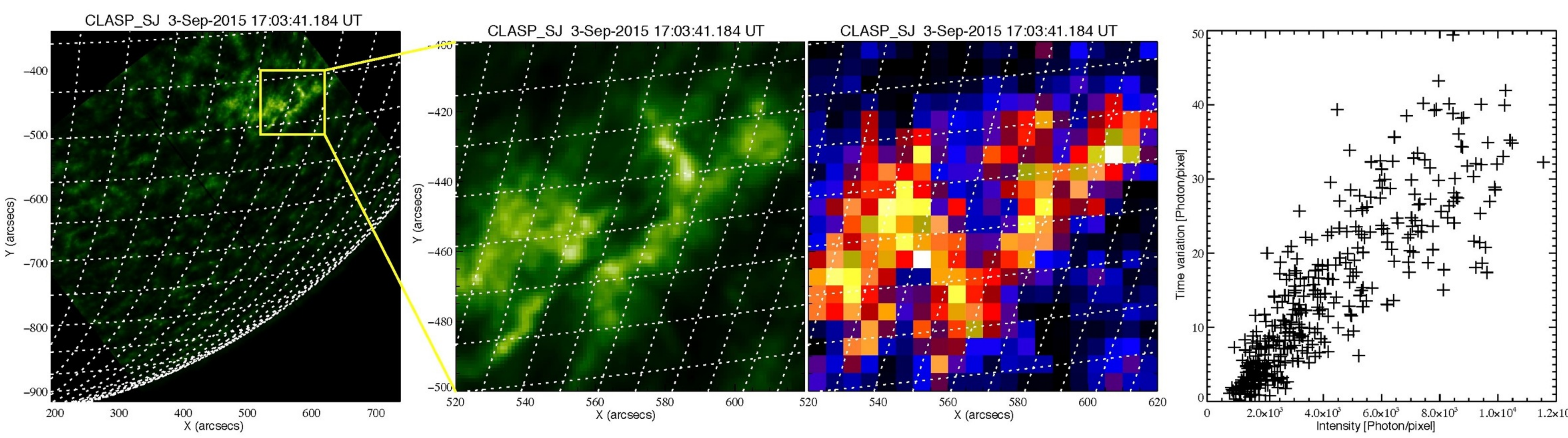
Abstract

The Chromospheric Lyman-alpha SpectroPolarimeter (CLASP) is a sounding rocket experiment launched on September 3, 2015 to investigate the solar chromosphere, and the slit-jaw (SJ) optical system took Lyα images with the high time cadence of 0.6 s. By the CLASP/SJ observation, many time variations in the solar chromosphere with the time scale of <1 minute were discovered (see the poster by Kubo et al., Pa-13). We focused on an active region and investigated the short (<30 s) time variations and relation to the coronal structure observed by SDO/AIA. We compared the Lyα time variations at footpoints of coronal magnetic fields observed by AIA 211 Å (~2 MK) and AIA 171 Å (0.6 MK), and non-loop regions. As the result, we found the <30 s Lyα time variations had more in the foopoint regions. On the other hand, the <30 s time variations had no dependency on the temperature of the loop.

High cadence Lyman-alpha observation by CLASP/SJ

An active region with relatively low activity level was in side the CLASP/SJ field of view, and we investigated the time variations there and compared with the active region structure. To focus on the short time scale, we investigated the images subtracted by the 30 s running averaged images. Although the time variation was relatively small compared to the intensity, we found the time variations with the time scale of <30 s and the spatial scale of a few arcseconds.

We binned the image with 5'' x 5'' boxes and evaluate <30 s time variations by calculating a standard deviation of a lightcurve for each 5'' x 5'' box. By comparing with the Lyα intensities in the boxes, we found that the areas with high Lyα intensities have more <30 s time scale temporal variations.



Left two panels: Snapshot of CLASP/SJ Lyα observation. Right two panels: 5'' x 5'' binned time variation map calculated by standard deviations of the lightcurves, and the relation of the intensities and time variations for 5'' x 5'' boxes.

Comparison with the active region structure

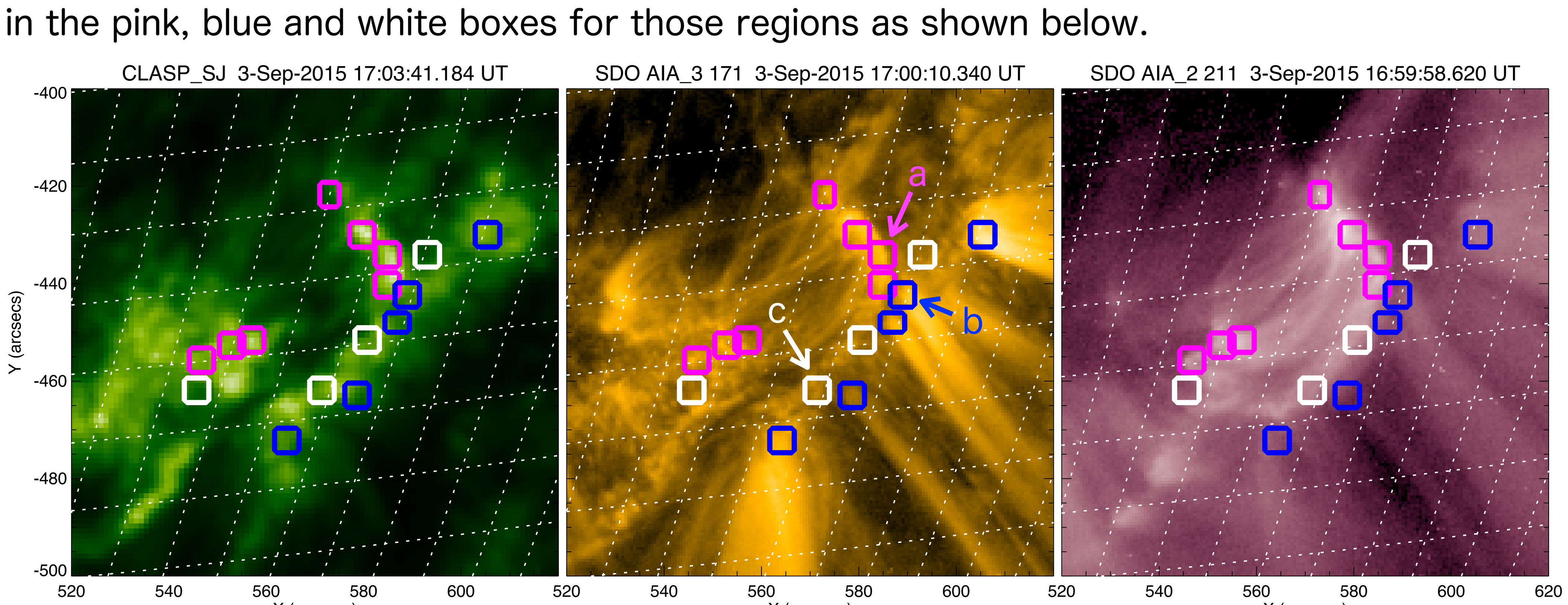
By looking at SDO/AIA images, the active region can be classified by three types of areas:

(1) Footpoints of closed loops observed by relatively high temperature lines such as 211 Å (sensitivity peak temperature: ~2 MK)

(2) Footpoints of relatively low temperature and open magnetic field seen by 171 Å (sensitivity peak temperature: ~0.6 MK)

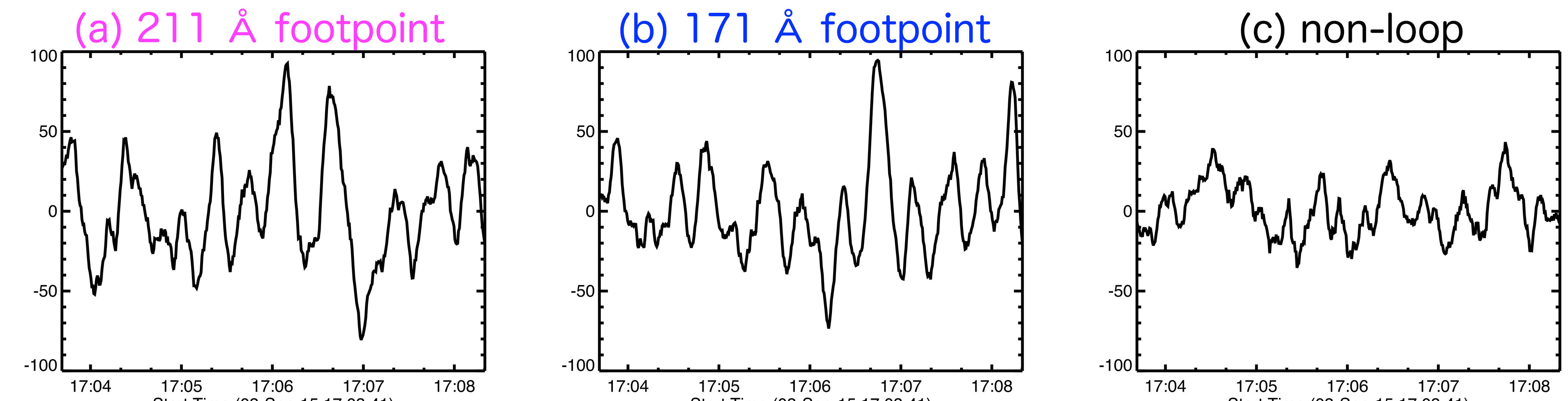
(3) Non-footpoint regions

By checking the CLASP/SJ and AIA images, we defined several 5'' x 5'' regions as shown in the pink, blue and white boxes for those regions as shown below.



CLASP/SJ, AIA 171 Å and 211 Å images with higher and lower temperature footpoints (pink and blue), and non-loop region (white)

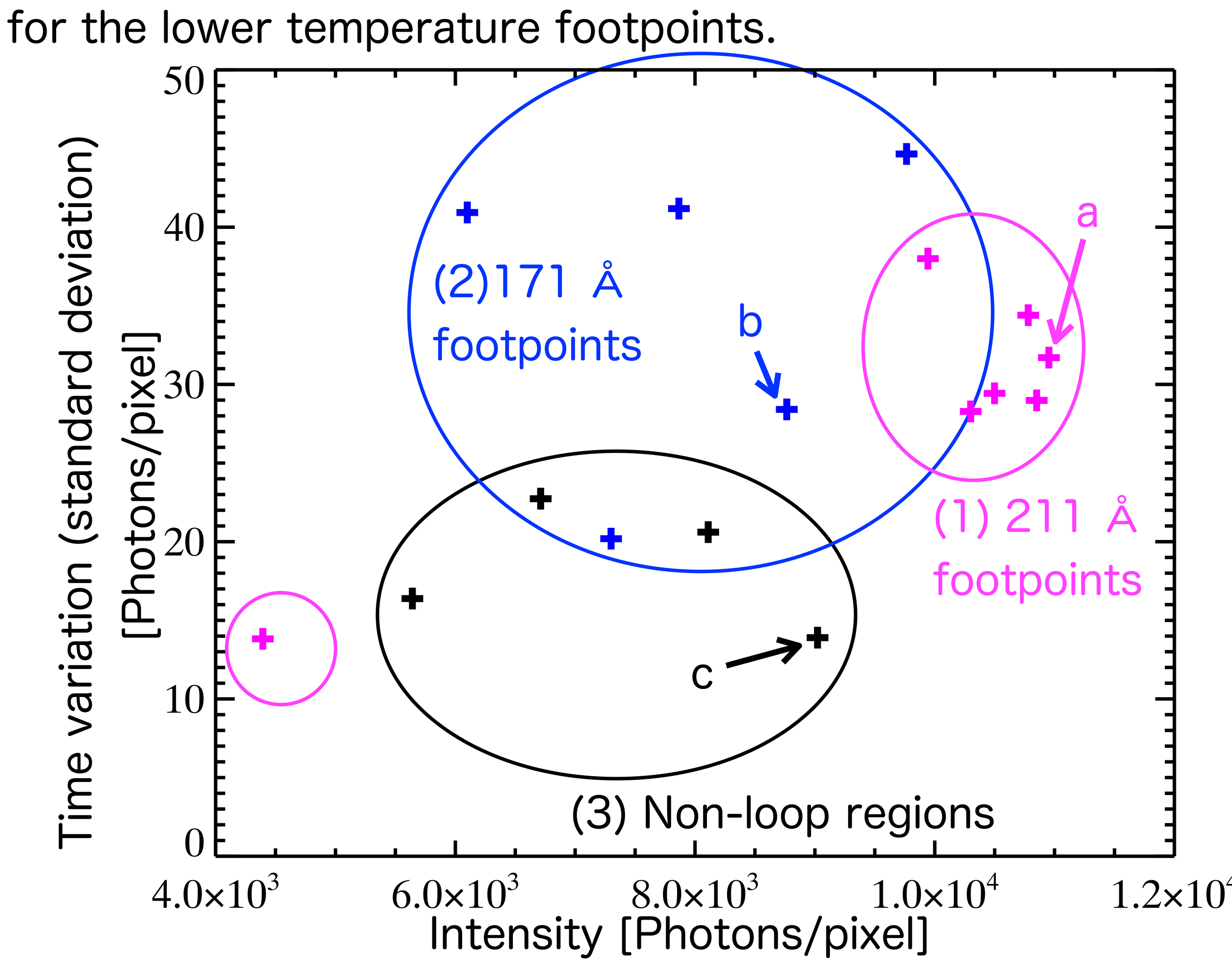
In the time profiles, we found that footpoint regions have more time amplitudes and non-loop regions have less time variations. In the footpoint regions, no significant difference in time variations can be seen between lower and higher temperature footpoints.



Examples of the time profiles of Lyα intensities at footpoints with higher and lower temperatures (left and center), and non-loop region (right)

Discussion

The figure below shows the relation between Lyα intensity and time variations calculated by the standard deviations of the lightcurves (influence by the photon noise was subtracted). It can be seen that the footpoint regions have more time variations. Although the higher temperature footpoints has higher intensities, the time variations are in the same range as for the lower temperature footpoints.



Relation between the Lyα intensities and the time variations calculated by the standard deviations of the lightcurve.

Since the amplitude of the time variation is clearly large in the footpoint regions, this phenomenon may contribute to heating of the coronal structure up to at least the peak temperature of 171 Å line of ~0.6 MK. The fact that no dependency of the <30 s time variation on temperature is found could be explained by two scenarios; (i) the mechanism to heat the loops to higher temperature is not related to the <30 s Lyα time variations, or (ii) the energy inputs are the same and temperature difference is caused by the difference in the spatial structures (i.e. loop lengths).